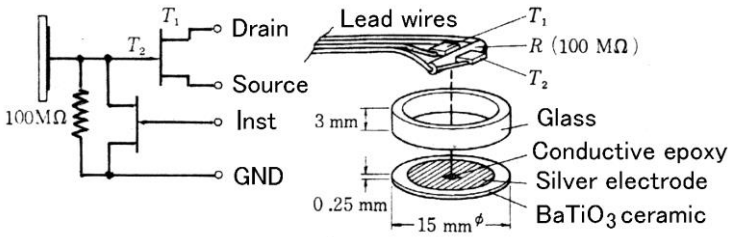
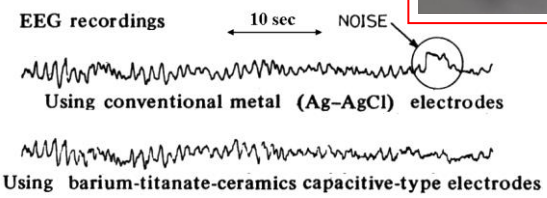
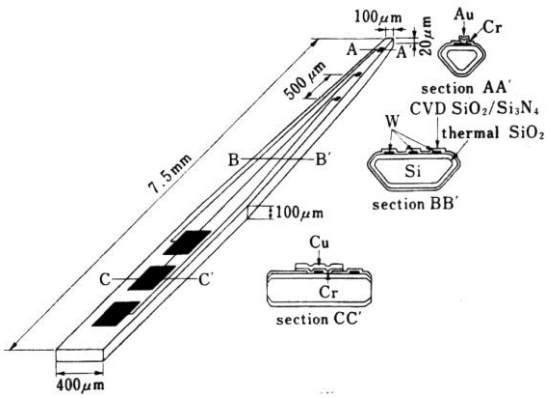
D1 Electrode for biopotential recording

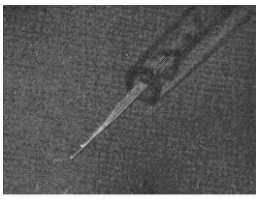


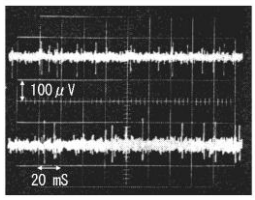


Capacitive electrode

Reference : T.Matsuo, M.Esashi, K.Iinuma, Capacitive Electrode for Biomedical Use (—the Use of Barium-titanate Ceramics for Biomedical Sensing Electrode—), Medical Electronics and Biomedical Engng., 11 (1973) pp.156-162
T.Matsuo, K.Iinuma and M.Esashi, A Barium-Titanate-Ceramics Capacitive-Type EEG Electrod, IEEE Trans.on Biomedical Engineering, BME-20 (1973) pp.299-300

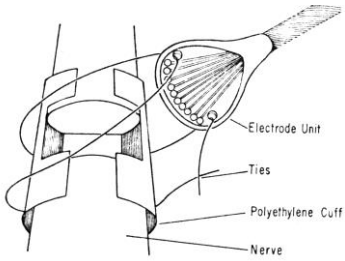


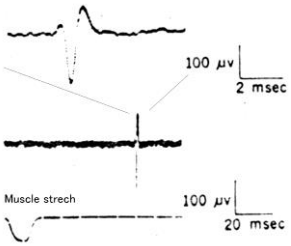


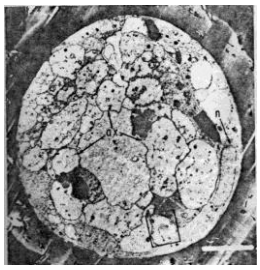


Micro multielectrode　　Flexibl multilectrodes

Reference : Y.Ohta, M.Esashi, T.Matsuo, Multielectrode Fabrication for Simultaneous Recording of Nerve Impulses Using IC Techniques, Medical Electronics and Biomedical Engng., 19 (1981) pp.106-113
T.Matsuo, A.Okitsu, M.Esashi, Fabrication of Flexible Multi Electrode for Biomedical Use, Tohoku region meeting of Electrical Eng., 1B11 (1978)

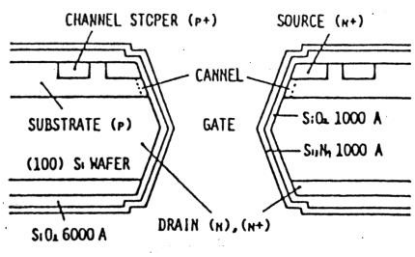


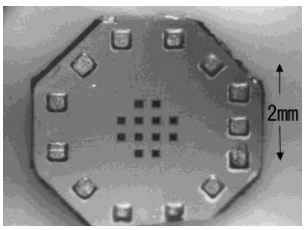


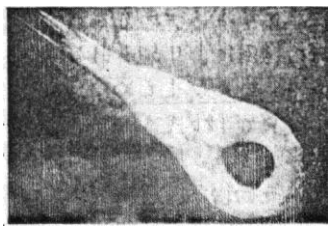


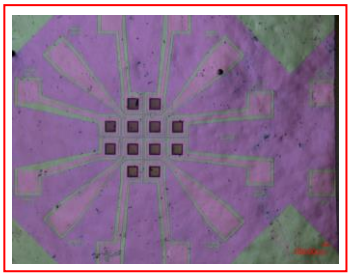
Nerve regeneration electrode (Univ. of Alberta, Canada)

Reference : A.Mannard, R.B.Stein and D.Charles, Regeneration Electrode Units : Implants for Recording from Single Peripheral Nerve Fibers in Freely Moving Animals, Science, 183 (1974) pp.547-549





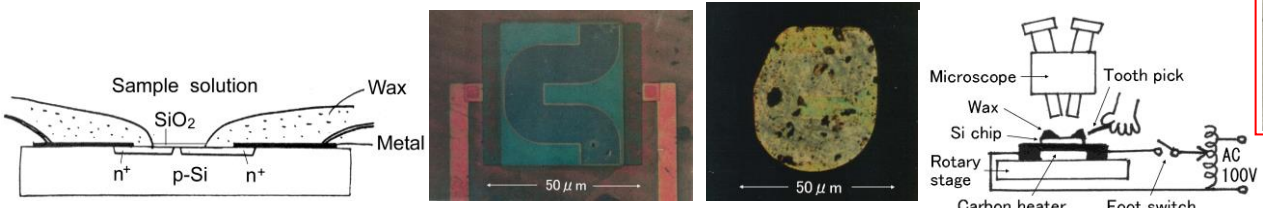




Nerve regeneration electrode using open gate MOSFET

Reference : A.Yamaguchi, T.Matsuo, M.Esashi, Fabrication of Multi-Hole-Active Electrode for Nerve Bundle, 17th Convention of Japan Soc. ME & BE (1978) p.261

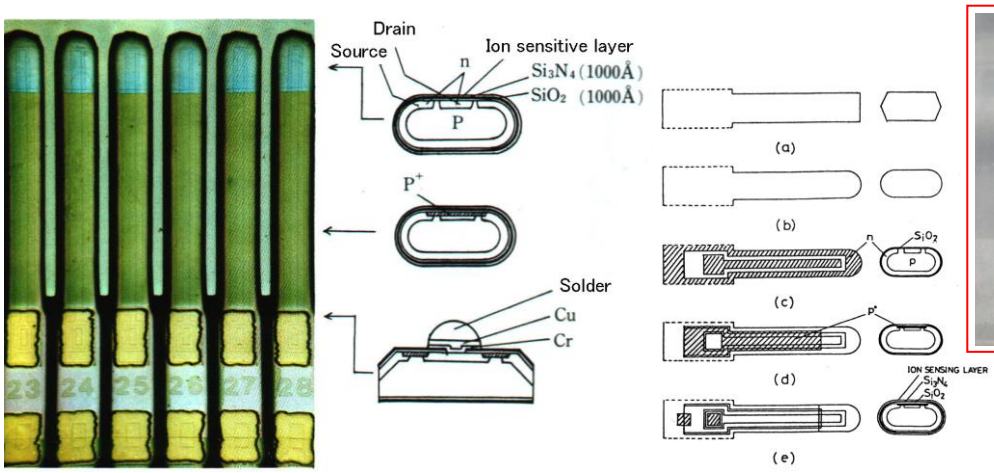
D2 Semiconductor ion sensor (ISFET)

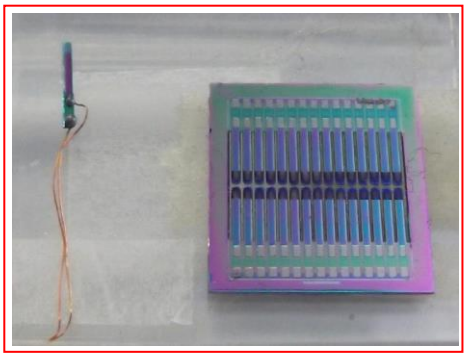


Medical active electrode

Reference : T.Matsuo, M.Esashi, K.Iinuma, Medical Active Electrode Using Field Effect of Semiconductor(1), Tohoku Convention in Electrical Soc.. (1971) p.28

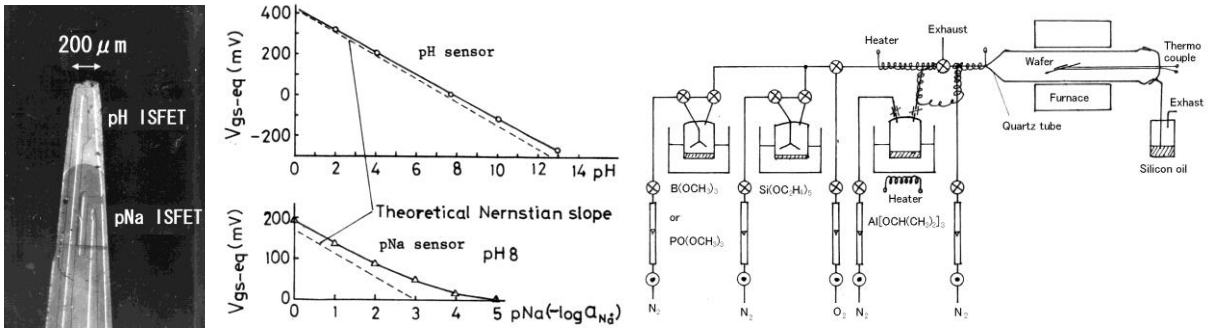
M.Esashi, T.Matsuo, Medical active electrode using field effect of semiconductor－Operation as a cation selective electrode－, 12th Convention ME&BE, (1973) pp.507-508





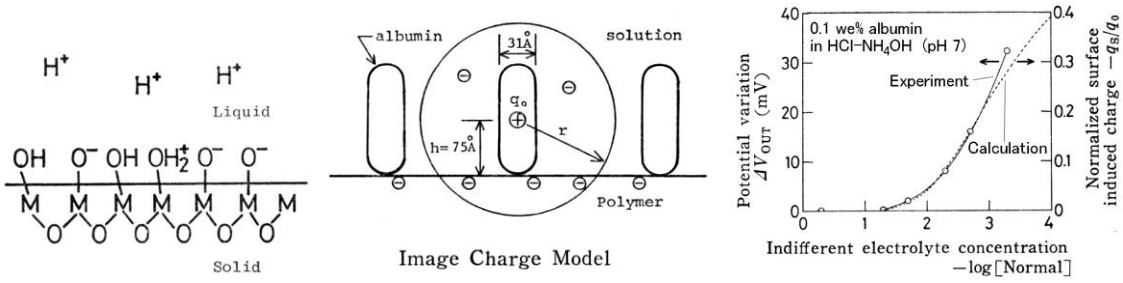
ISFET (Ion Sensitive Field Effect Transistor)

Reference : M.Esashi and T.Matsuo, Biomedical Cation Sensor Using Field Effect of Semiconductor, J. of the Japan Soc. of Applied Physics, 44, Supplement (1975) pp.339-343



Multi ion sensitive ISFET

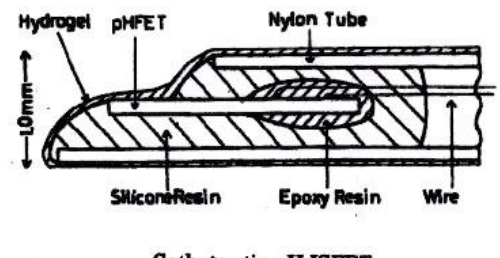
Reference : M.Esashi and T.Matsuo, Integrated Micro Multi Ion Sensor Using Field Effect of Semiconductor, IEEE Trans. on Biomedical Engineering, BME-25 (1978) pp.184-192



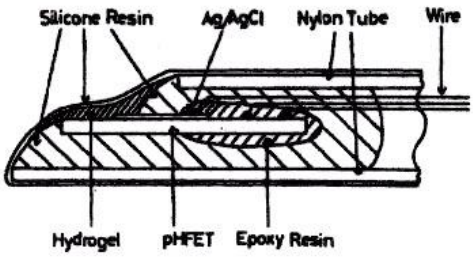
Polymer gate FET

Reference : H.Nakajima, M.Esashi and T.Matsuo, The pH-response of Organic Gate ISFETs and the Influence of Macro-molecule Adsorption, J. of Chemical Soc. of Japan, 10 (1980) pp.1499-1508

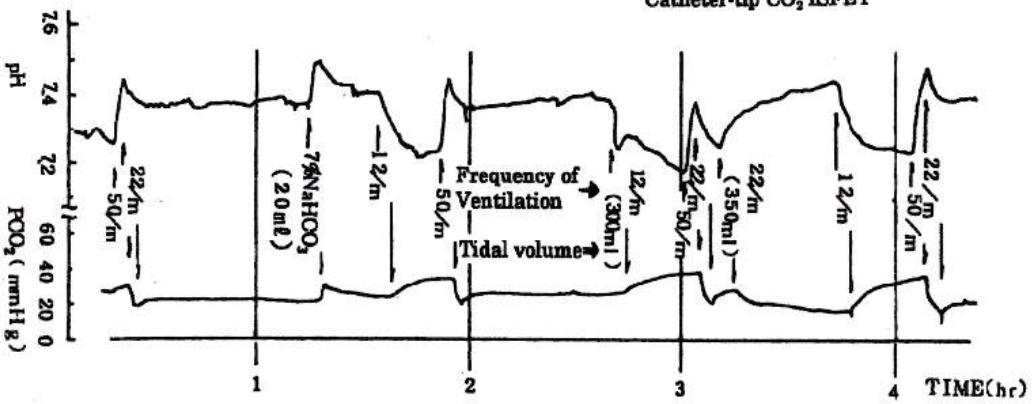
D3 Catheter pH, CO_2 sensor



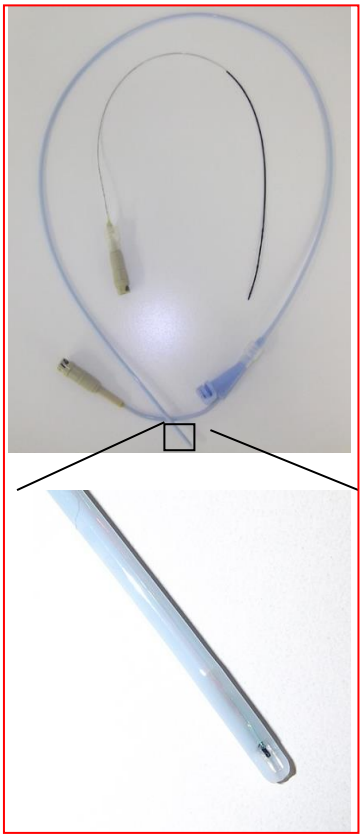
Catheter-tip pH ISFET



Catheter-tip CO_2 ISFET

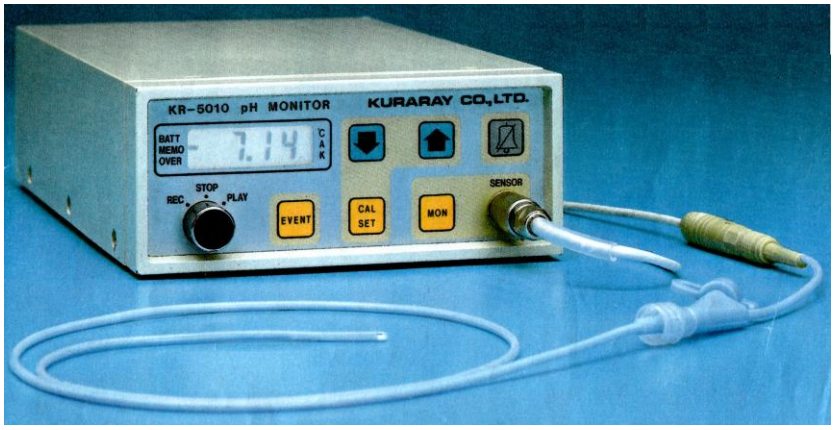


Continuous pH and CO_2 measurement of sed arterial blood of mongral dog by the catheter-tip pH ISFET and catheter-tip CO_2 ISFET.

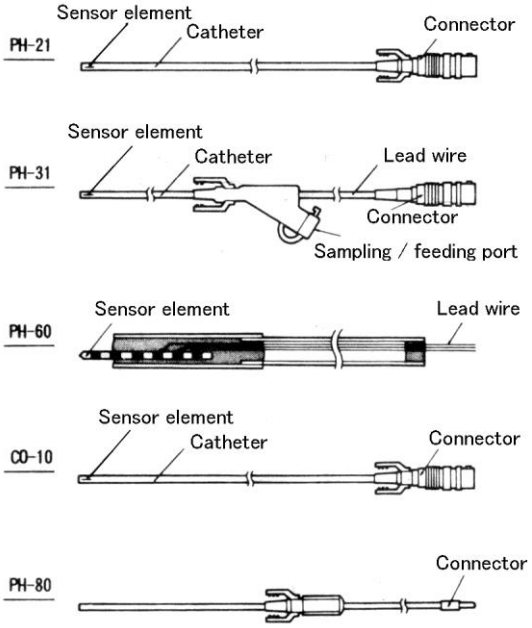


Catheter pH, CO_2 sensor (Kurare – Tohoku Univ.)

Reference : K.Shimada, M.Yano, K.Shibatani, Y.Komoto, M.Esashi and T.Matsuo, Application of Catheter-tip I.S.F.E.T. for Continuous in Vivo Measurement, Med.& Biol.Eng. & Comput., 18 (1980) pp.741-745



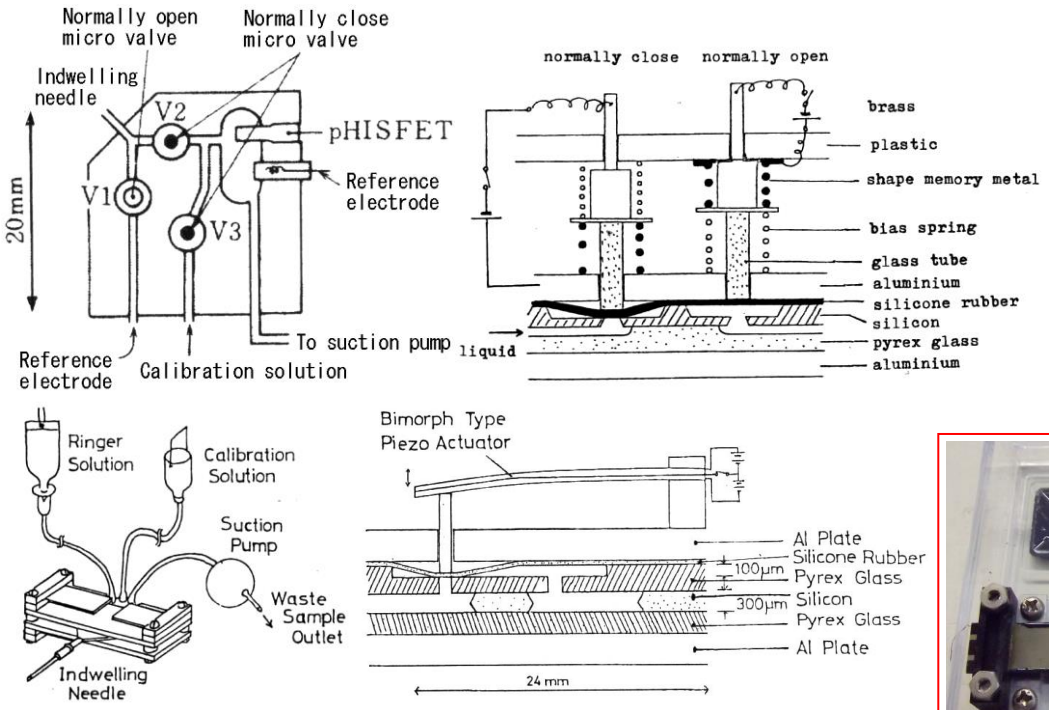
Catheter pH, CO_2 sensor commercialized in 1980 (Kurare, Nohon Kohden)

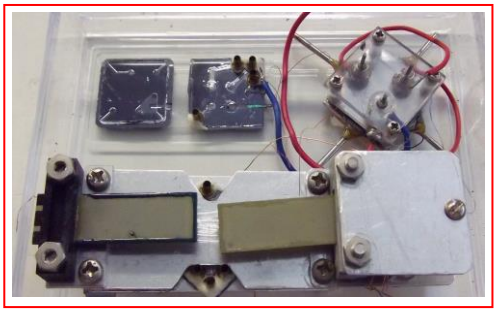


NIHON KOHDEN

Type	Application	No	Catheter (mm)		Monitor	Note
			Length	Diameter		
PH-21	pH measurement in muscle etc	PH-2135	350	1.1	KR-5000	With reference
PH-31	pH measurement in esophagus and stomach	PH-3110 (Adult)	1000	2.4	KR-5000	With reference and feed port
		PH-3165 (Infant)	650	2.4	KR-5010	
PH-60	pH measurement in mouth	PH-6010	100	1.0	KR-5000	Without reference
PH-80	Reference electrode for PH-60	PH-8005	50	1.1	KR-5000	
CO-10	PCO_2 measurement in muscle etc	CO-1035	350	0.9	KR-5000	With reference

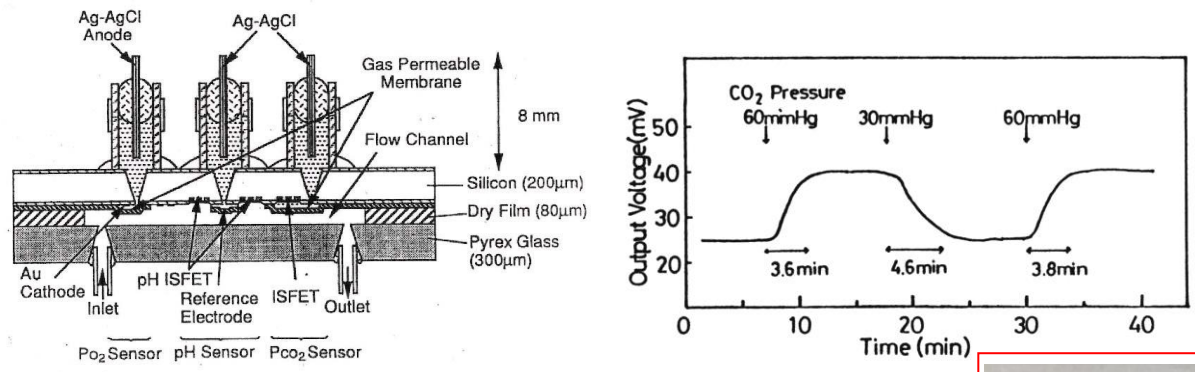
D4 Intermittent sampling continuous blood gas monitor

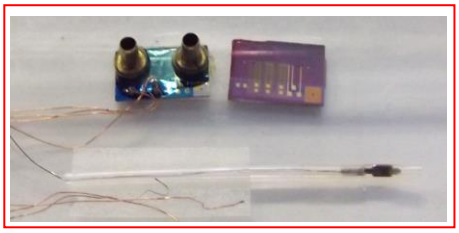




Intermittent sampling blood gas monitor

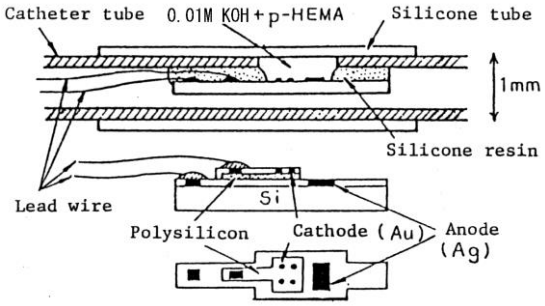
Reference : S.Shoji, M.Esashi and T.Matsuo, Prototype Miniature Blood Gas Analyser Fabricated on a Silicon Wafer, Sensors & Actuators, 14 (1988) pp.101–107

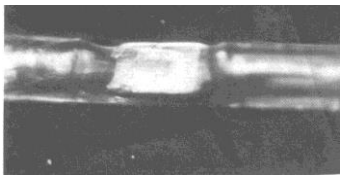


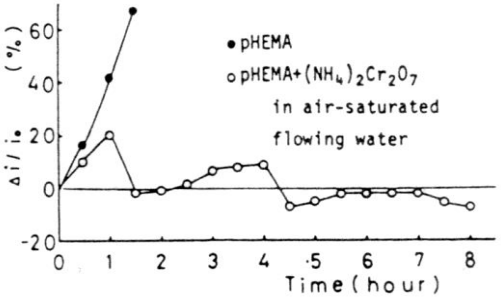


Flow cell for continuous blood gas analysis

Reference : S.Shoji and M.Esashi, Micro Flow Cell for Blood Gas Analysis Realizing Very Small Sample Volume, Sensors and Actuators B, 8 (1992) pp.205–208



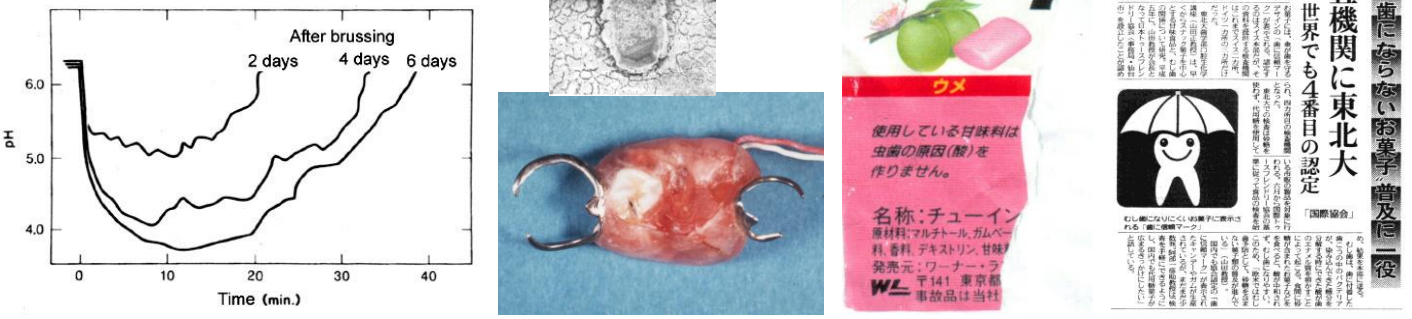




Clark type oxygen sensor in blood vessel

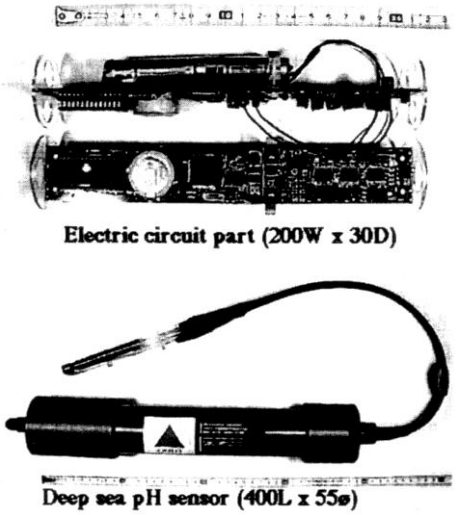
Reference : M.Esashi, A.Nishikawa, T.Matsuo, Fabrication of Micro Oxygen Sensor by IC Techniques, Technical Report of ICEC, MBE81-36 (1981)

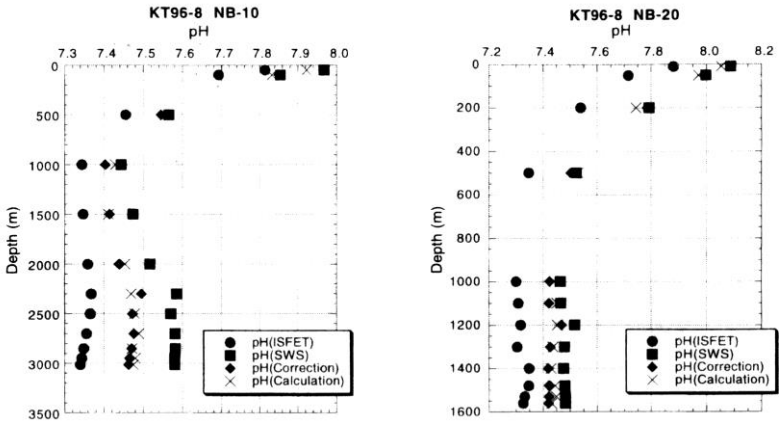
D5 Application of ISFET to dentistry, oceanography and fish cultivation



pH measurement of teeth

Reference : R.Chida, K.Igarashi, K.Kamiyama, E.Hoshino and M.Esashi, Characterization of Human Dental Plaque Formed on Hydrogen-ion-sensitive Field-effect Transistor Electrodes, J. of Dental Research, 65 (1986) pp.448-451





Vertical profiles of pH obteined by ISFET-pH sensor (●), on board analysis (■ : glass electrode at 25℃ ; SWS scale), correction with *in situ* temperature and pressure (◆) and calculation from total carbonate and alkalinity (×).

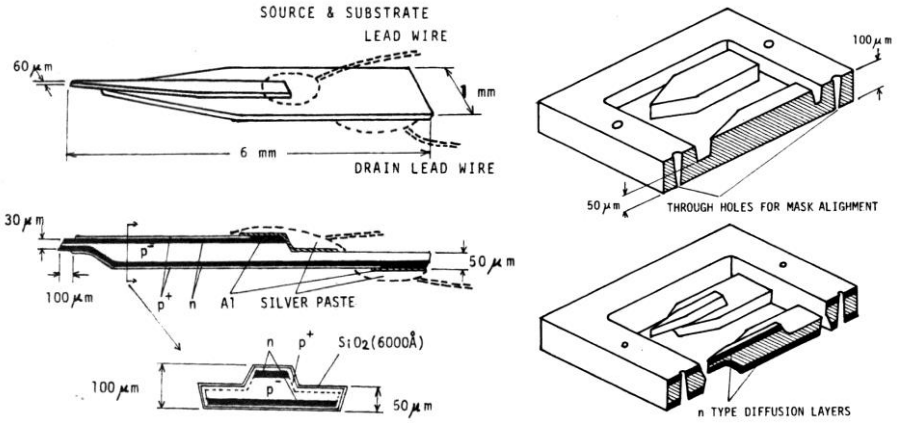
Application of ISFET to oceanography (Central Research Institute of Electrical Power Industry, Japan Marine Science and Technology Center)

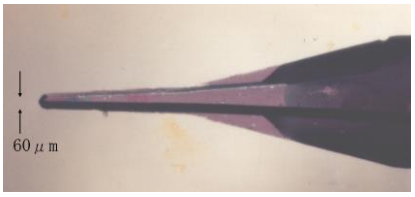
Reference : K.Shitashima and M.Kyo, Application of Chemical Sensors to Oceanography — Development of Deep Sea pH Sensor Using ISFET —, Geochemistry, 32 (1998) pp.1-11

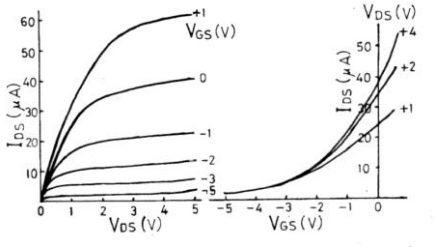
Portable pH sensor (Shindengen Kogyo)

Reference : Y.Ito, Development of ISFET and pH Sensors, Chemical Sensors, 14 (1998) pp.8-17

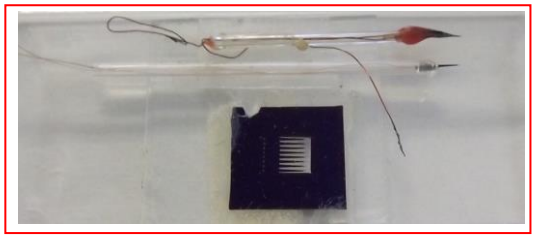
D6 Micro ISFET and integrated micro probe



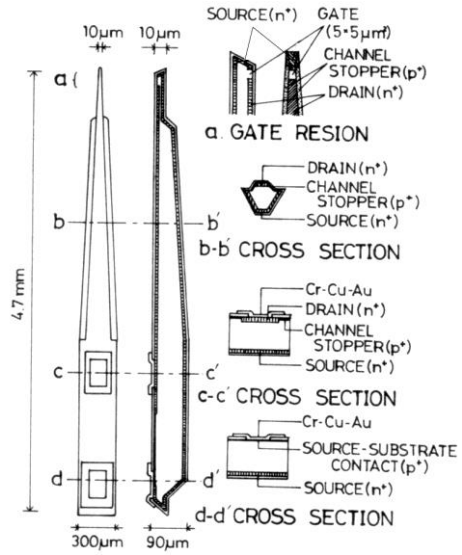


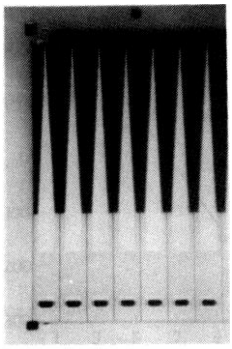


Micro ISFET with 60 μm tip

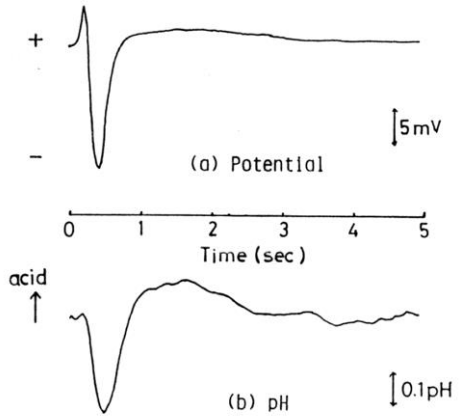


Reference : M.Esashi and T.Matsuo, Biomedical Cation Sensor Using Field Effect of Semiconductor, J. of the Japan Soc. of Applied Physics, 44, Supplement (1975) pp.339–343



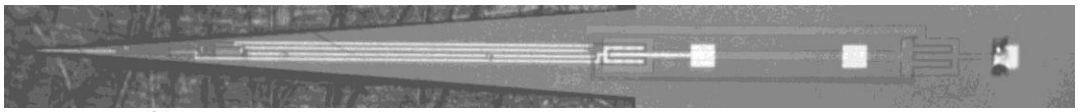


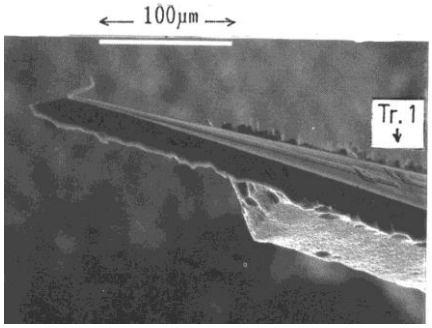
Micro ISFET with 10 μm tip

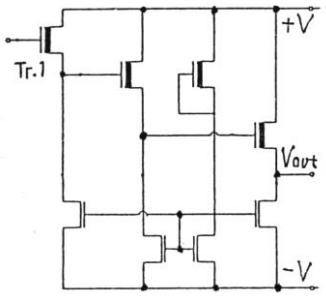


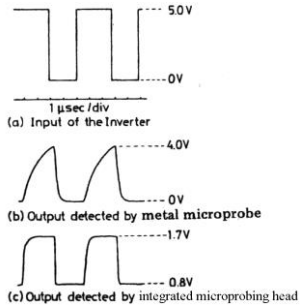
Activation potential and pH after light stimulation

Reference : S.Shoji, M.Esashi and T.Matsuo, Prototype Micro ISFET for Biomedical Research, Electronics and Communications in Japan, Part 2, 69 (1986) pp.21–29





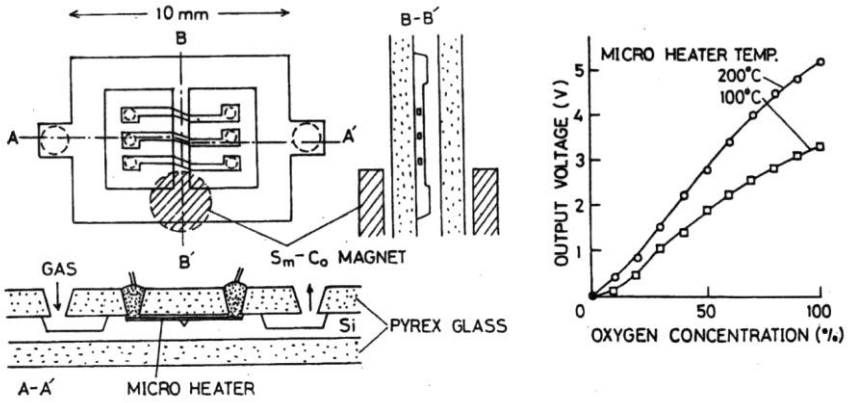


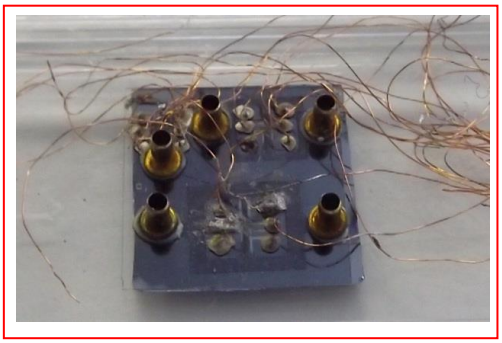


Integrated micro probe

Reference : S.Shoji, M.Esashi and T.Matsuo, Fabrication of an Integrated Micro Probing Head for Fault Analysis of MOS Integrated Circuits, Sensors & Actuators, 14 (1988) pp.125–132

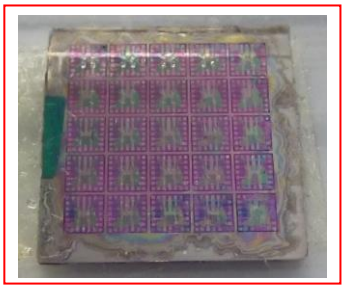
D7 Gas sensors

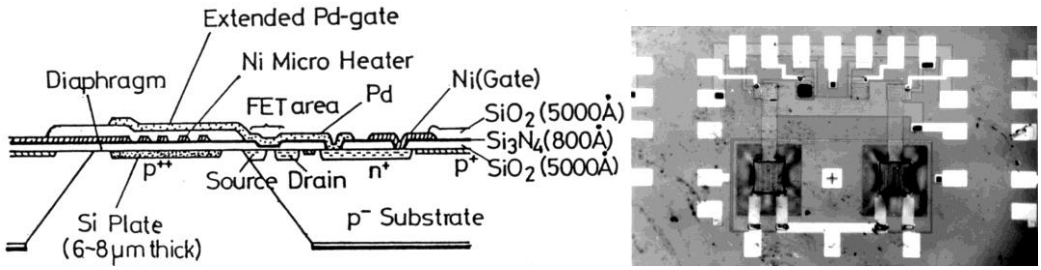




Magnetic oxygen sensor

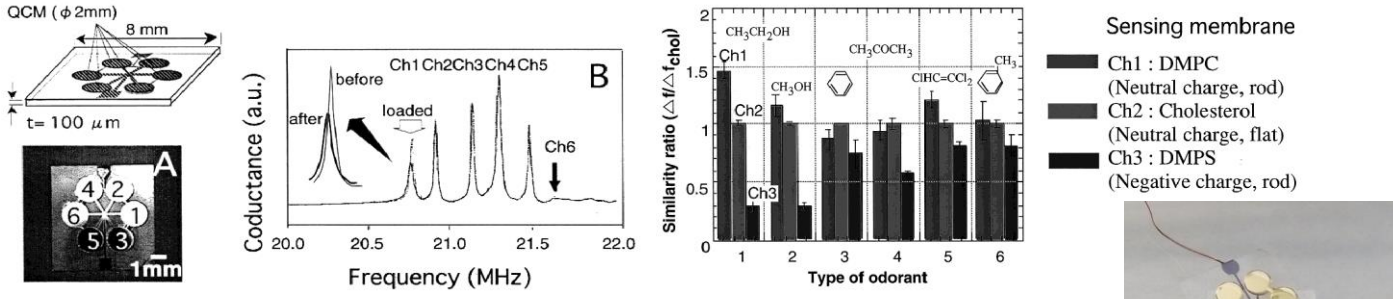
Reference : M.Esashi, Micro Flow Sensor and Integrated Magnetic Oxygen Sensor Using It, Digest of Technical Papers Transducers'91 (1991) pp.34-37





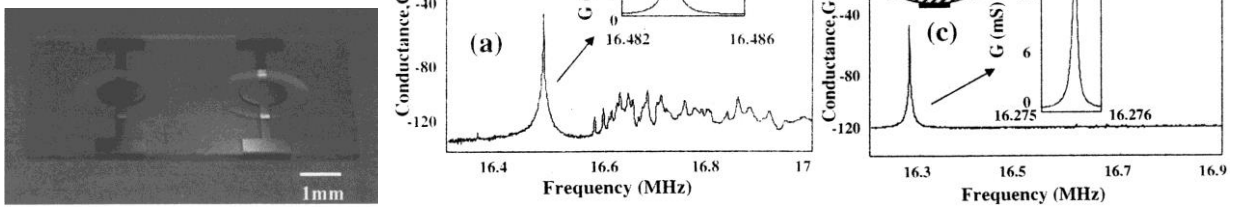
Extended palladium-gate FET (Tohoku Univ. – Linkoping Univ. of Tech.. (Sweden))

Reference : F.Enquist, M.Esashi, M.Armgarth, I.Lundstrom and T.Matsuo, Design of a High Temperature Extended Palladium-gate Field Effect Transistor for the Detection of Organic Molecules, Digest of Technical Papers, The 4th Int.Conf.on Solid State Sensors and Actuators (1987) pp.644-648



Multi QCM by deep RIE of quartz

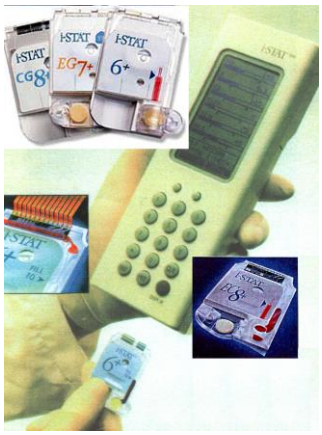
Reference : T.Abe and M.Esashi, One-chip Multichannel Quartz Crystal Microbalance (QCM) Fabricated by Deep RIE, Sensors and Actuators, A82 (2000) pp.139-143

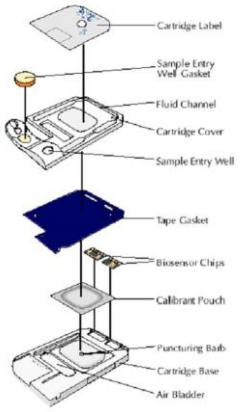


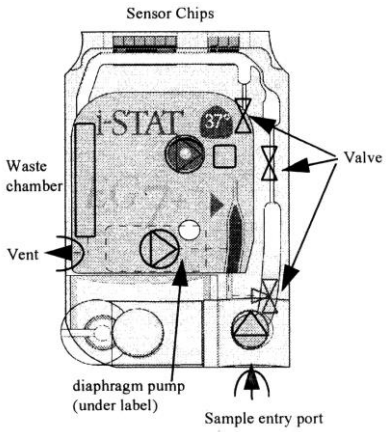
Bi-convex QCM

Reference : L.Li, T.Abe and M.Esashi, Fabrication of Miniaturized Bi-convex Quartz Crystal Microbalance Using Reactive Ion Etching and Melting Photoresist, Sensors & Actuators A, 114 (2004) pp.496-500

D8 Disposable chemical analysis chip

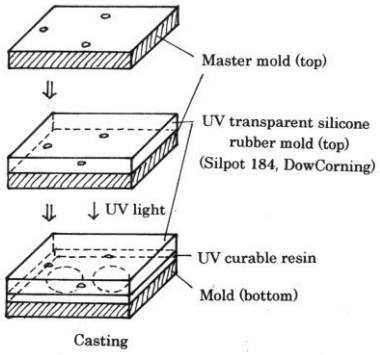


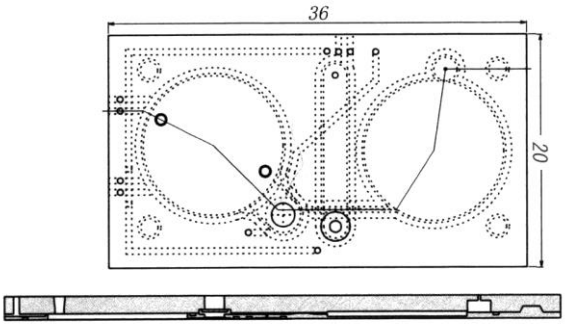




Blood analysis chip (i-STAT)

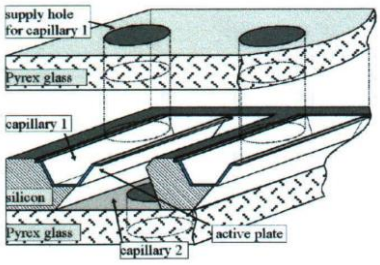
Reference : I.R.Larks, Microfabricated Biosensors and Microanalytical Systems for Blood Analysis, Acc. Chem. Res., 31 (1998) pp.317-324

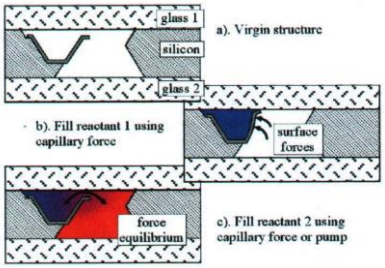




Absorptiometric blood analysis chip made of polymer UV imprinting (Tohoku Univ. - Sysmetics)

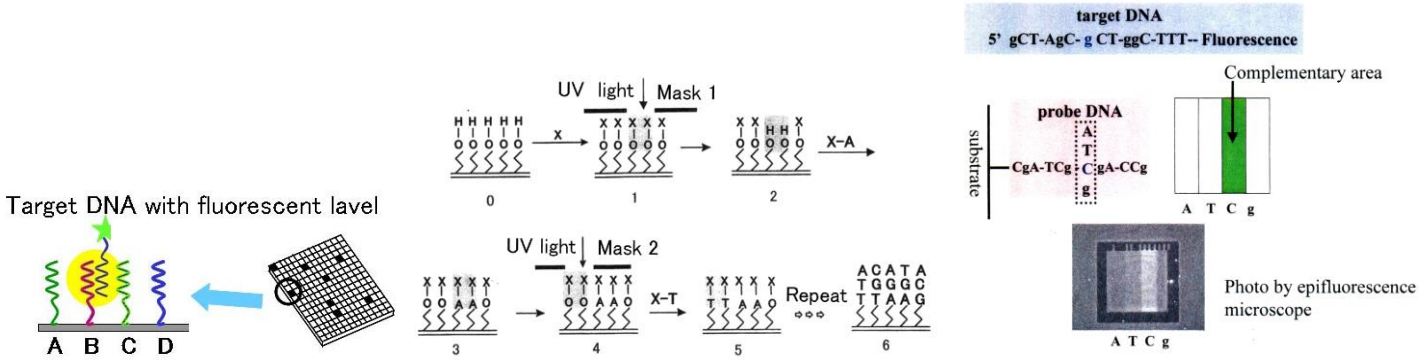
Reference : K.Sawa and M.Esashi : Micromolding of Disposable Polymer Parts for Medical Diagnostics, Technical Digest of the 18th Sensor Symposium (2001) pp.229-232





Absorptiometric analysis chip which hold chemical by surface tension (Tohoku Univ. - Friburg Univ. (Germany))

Reference : R.U.Seidel, D.Y.Sim, W.Menz and M.Esashi, A New Approach to On-Site Liquid Analysis, Sensors and Materials, 12 (2000) pp.57-68

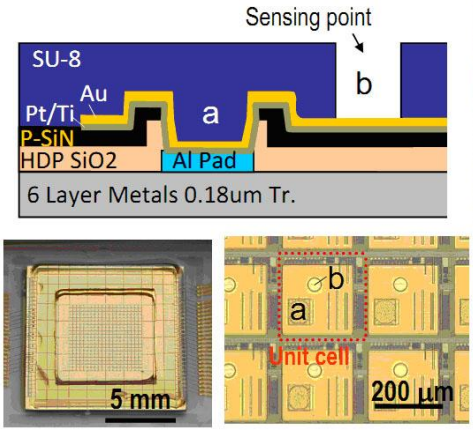


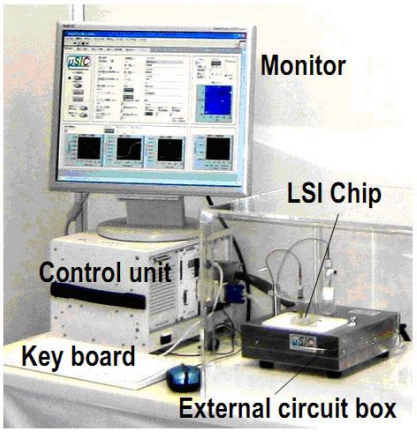
DNA chip for gene analysis for SNPS of lever cancer (Tohoku Univ. - Cancer Institute - Tokyo Institute of Technology)

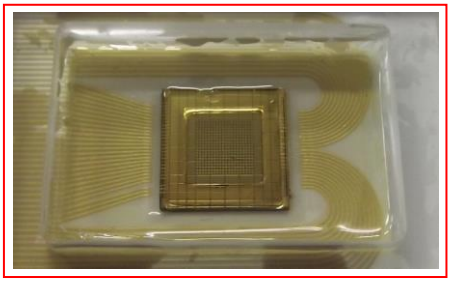
Reference : K.Takahashi, K.Seio, M.Sekine, O.Hino and M.Esashi, A Photochemical/chemical Direct Method of Synthesizing High-performance Deoxyribonucleic Acid Chips for Rapid and Parallel Gene Analysis, Sensors and Actuators, B83 (2002) pp.67-76

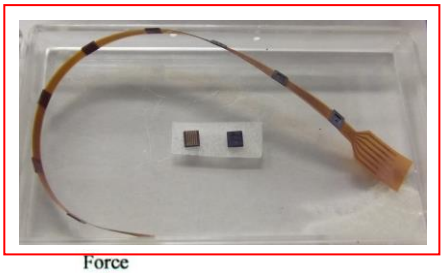
D9 Bio LSI and tactile sensor network

(Special Coordination Funds for Promoting Science and Technology,
Formation of Innovation Center for Fusion of Advanced Technologies)

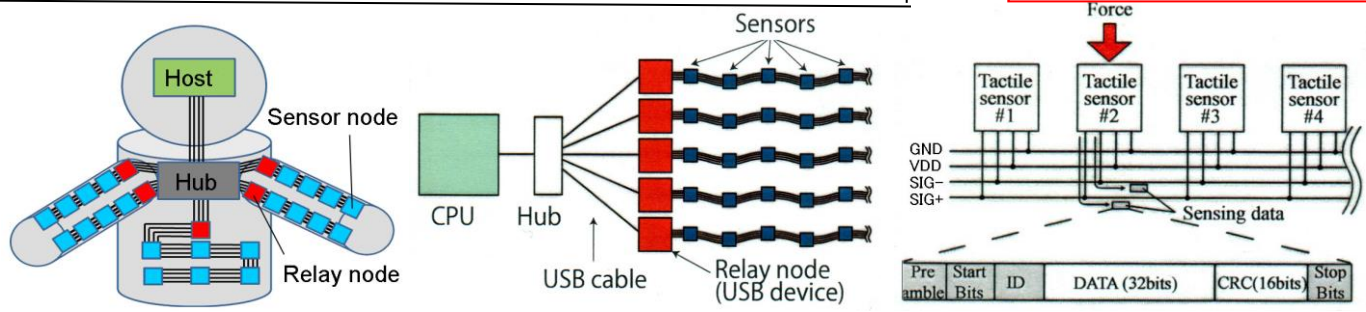




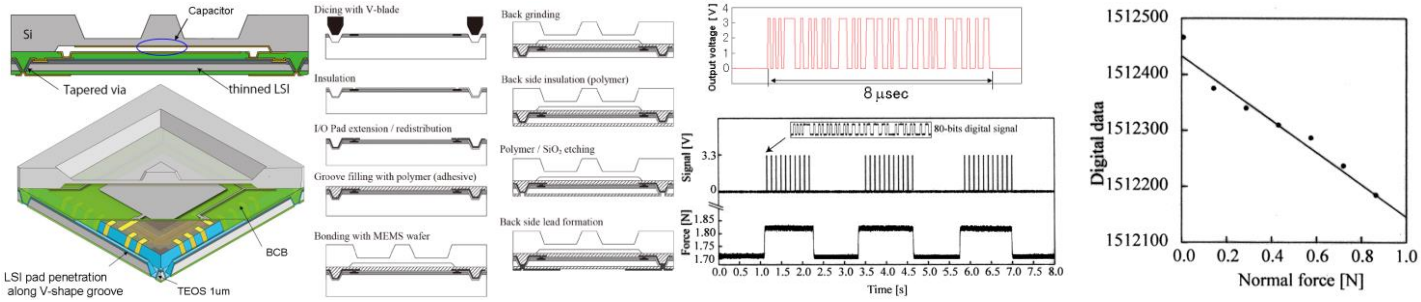




Bio LSI (Tohoku Univ. Matsue)

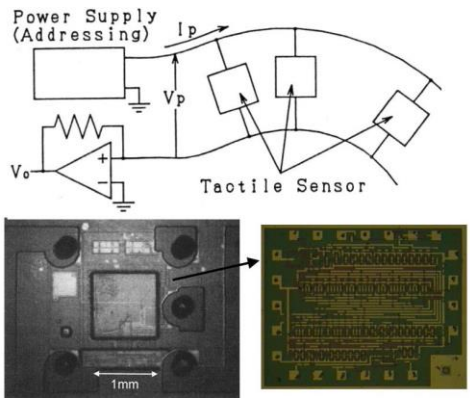


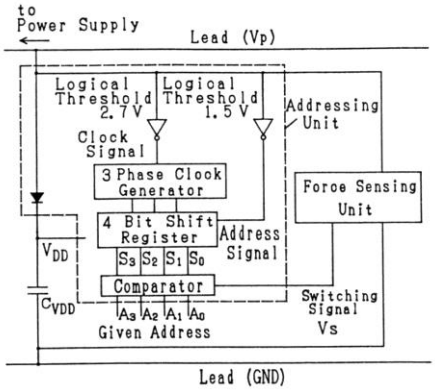
Event driven type tactile sensor network for nursing care robot (Tohoku Univ. – Toyota Motor – Toyota Central Research Laboratory)

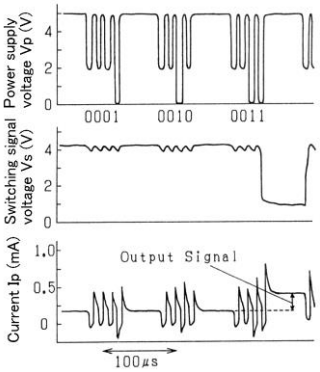


Tactile sensor for robot skin (Tohoku Univ. – Toyota Motor – Toyota Central Research Laboratory)

Reference : M.Muroyama, M.Makihata, Y.Nakano, S.Matsuzaki, H.Yamada, Ui.Yamaguchi, T.Nakayama, H.Nonomura, M.Fujiyoshi, S.Tanaka and M.Esashi, Development of an LSI for Tactile Sensor Systems on the Whole-Body of Robots, Trans. IEE of Japan, 131-E (2011) pp.302-309



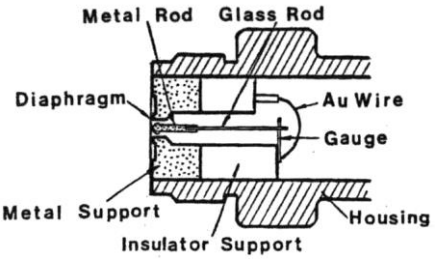


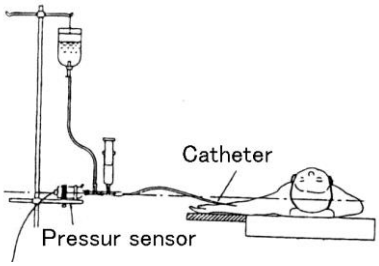


Tactile sensor network with polling type common 2-wire

Reference : S.Kobayashi, T.Mitsui, S.Shoji and M.Esashi, Two-Lead Tactile Sensor Array Using Piezo-resistive Effect of MOS Transistor, Technical Digest of the 9th Sensor Symposium (1990) pp.137-140

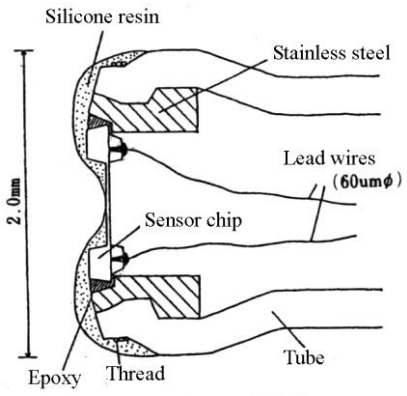
D10 Catheter blood pressure sensor

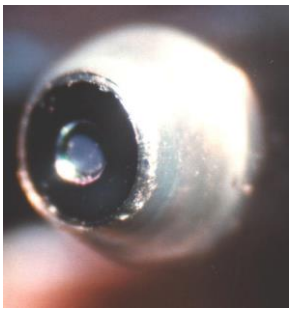


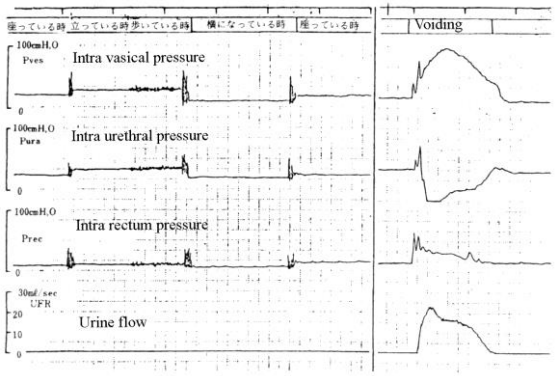


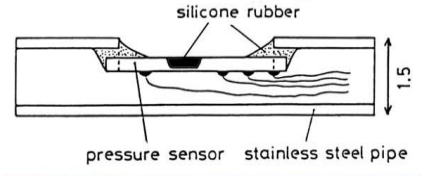
Blood pressure transducer with liquid filled catheter (Nihon Kohden – Tohoku Univ.)

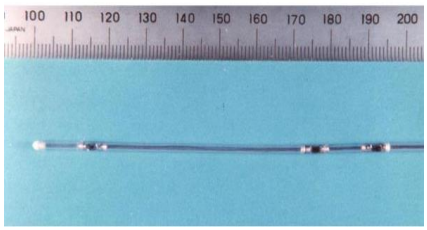
Reference : H.Ozawa, T.Shibuya, S.Takeda, M.Hyogo, T.Sekiguchi and M.Esashi, Property Improvement of Blood Pressure Transducers, 25th Convention of ME&BE, 3-PF-3 (1986)

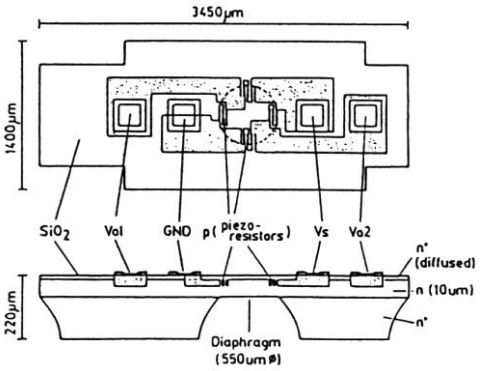


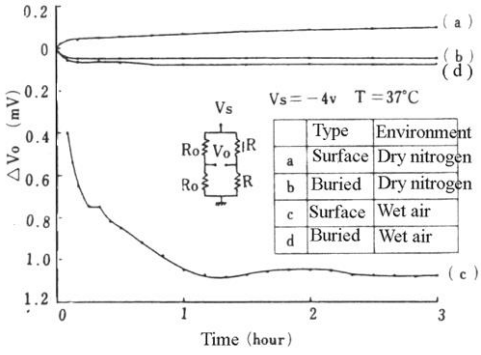








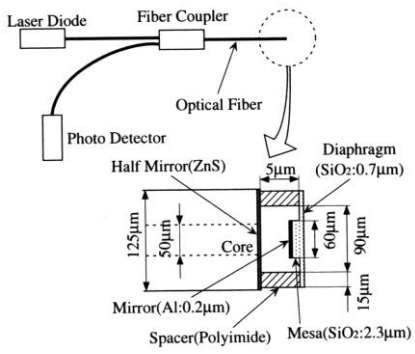


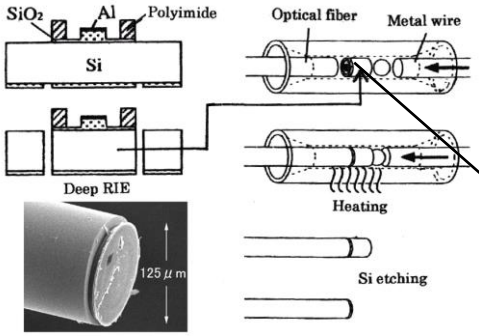


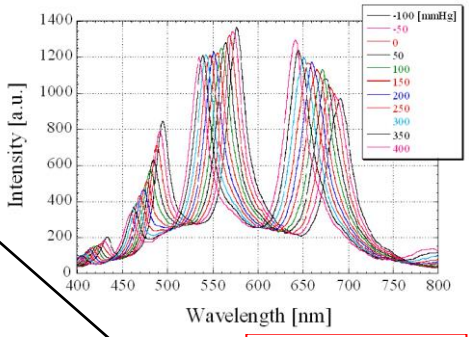
	Type	Environment
a	Surface	Dry nitrogen
b	Buried	Dry nitrogen
c	Surface	Wet air
d	Buried	Wet air

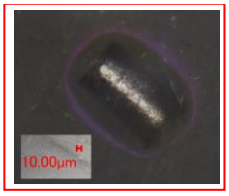
Piezoresistive multi pressure sensor catheter (Tohoku Univ. – Nihon Kohden)

Reference : M.Esashi, H.Komatsu, T.Matsuo, M.Takahashi, T.Takishima, K.Imabayashi and H.Ozawa, Fabrication of Catheter-tip and Sidewall Miniature Pressure Sensors, IEEE Trans. on Electron Devices, ED-29 (1982) pp.57-63





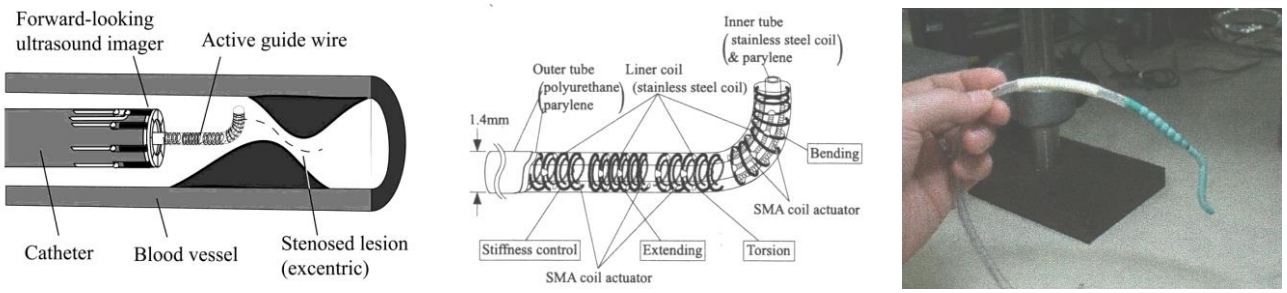




Small diameter fiber optic blood pressure sensor

Reference : T.Katsumata, Y.Haga, K.Minami and M.Esashi Micromachined, 125 μm Diameter Ultra Miniature Fiber-Optic Pressure Sensor for Catheter, Trans. IEE of Japan, 120-E (2000) pp.58-63

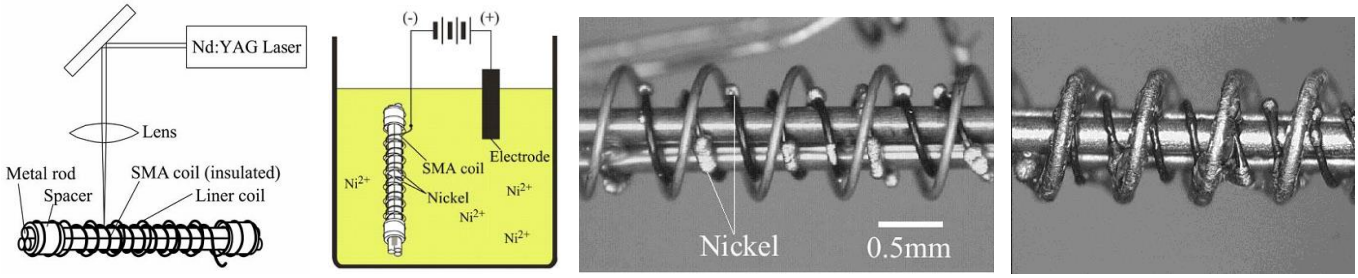
D11 Active catheter



Concept of multifunction active catheter

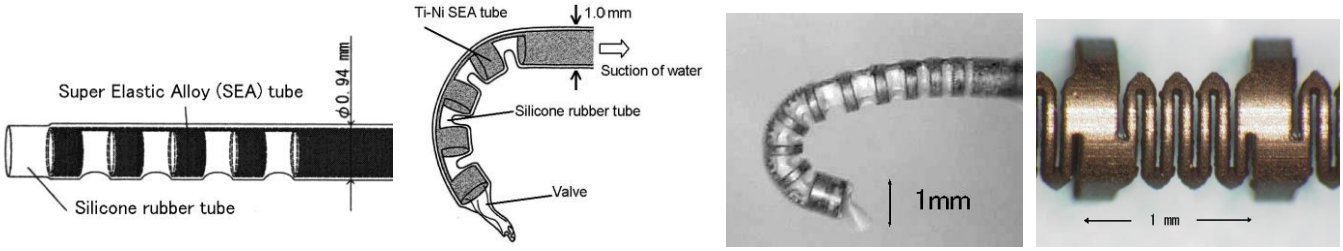
Active ileus tube

Reference : Y.Haga and M.Esashi, Biomedical Microsystems for Minimally Invasive Diagnosis and Treatment, Proc. of the IEEE, 92 (2004) pp.98-114



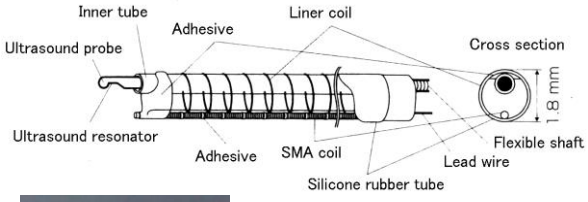
Assembly of multi-function active catheter using Shape Memory Alloy (SMA)

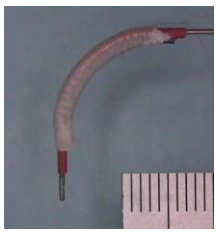
Reference : Y.Haga, M.Esashi, Assembly of Bending, Torsional and Extending Active Catheter Using Electroplating, Trans. IEE of Japan, 120-E (2000) pp.515-520



Suction type active catheter

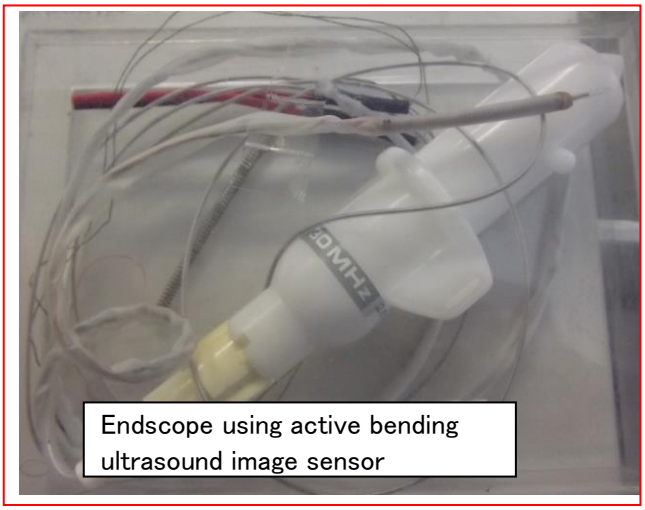
Reference : Y.Muyari, Y.Mineta, T.Mineta and M.Esashi, Development of Hydraulic Suction Type Active Catheter Using Super Elastic Alloy Tube, Proc. of the 20th Sensor Symposium (2003) pp.57-60





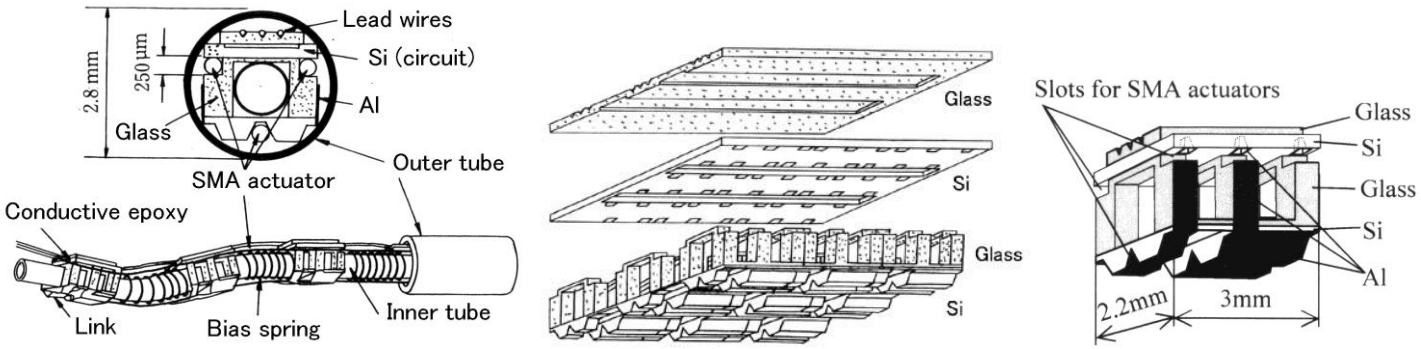
Small diameter ultrasound image sensor with active bending mechanism using SMA

Reference : Y.Haga, Y.Tanahashi and M.Esashi, Small Diameter Active Catheter Using Shape Memory Alloy, Proc. of IEEE MEMS'98 (1998) pp.419-424



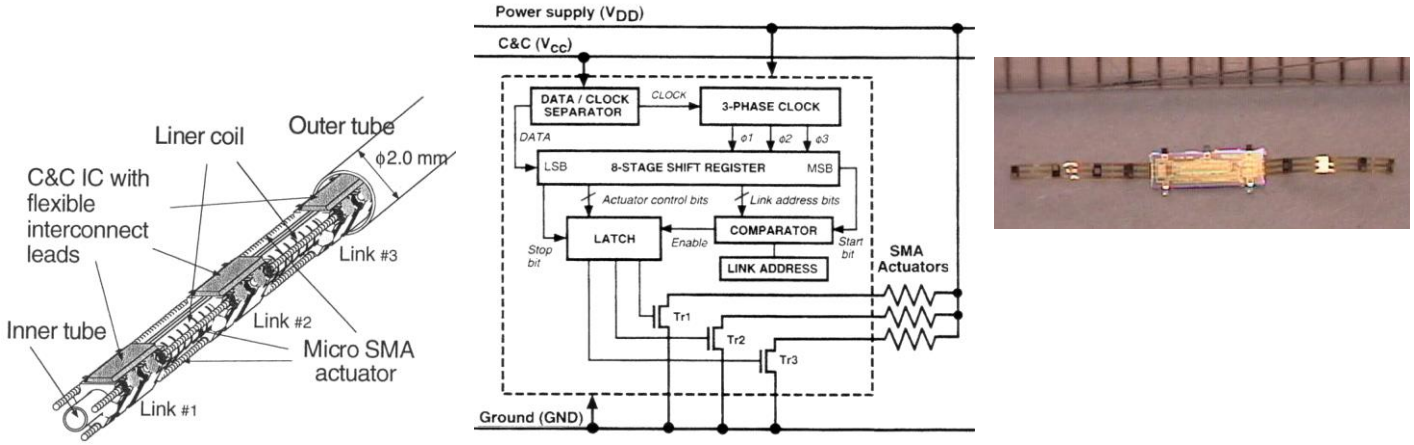
Endscope using active bending ultrasound image sensor

D12 Multi-link motion mechanism using shape memory alloy



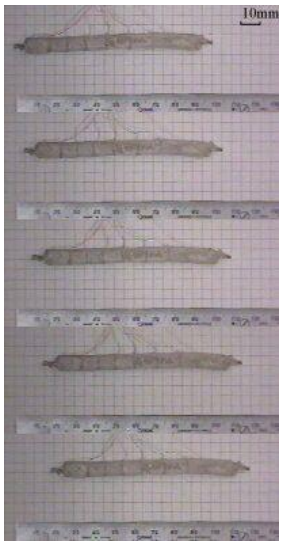
Multi-link Active Catheter using Shape Memory Alloy (SMA)

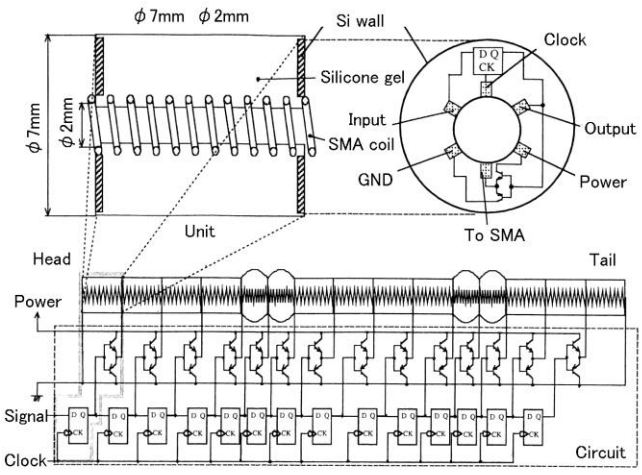
Reference : G.Lim, K.Minami, K.Yamamoto, M.Sugihara, M.Uchiyama and M.Esashi, Multi-link Active Catheter Snake-Like Motion, Robotica, 14 (1996) pp.499-506



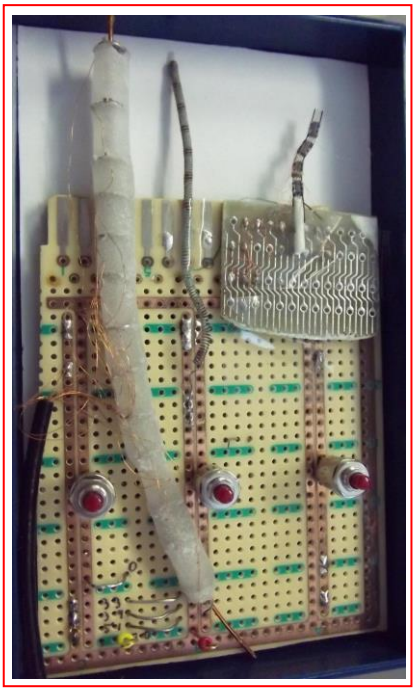
Multilink active catheter with common 2-wire integrated CMOS communication control circuits

Reference : K.-T.Park and M.Esashi, A Multilink Active Catheter with Polyimide-Based Integrated CMOS Interface Circuits, IEEE J. of Microelectromechanical Systems, 8 (1999) pp.349-357



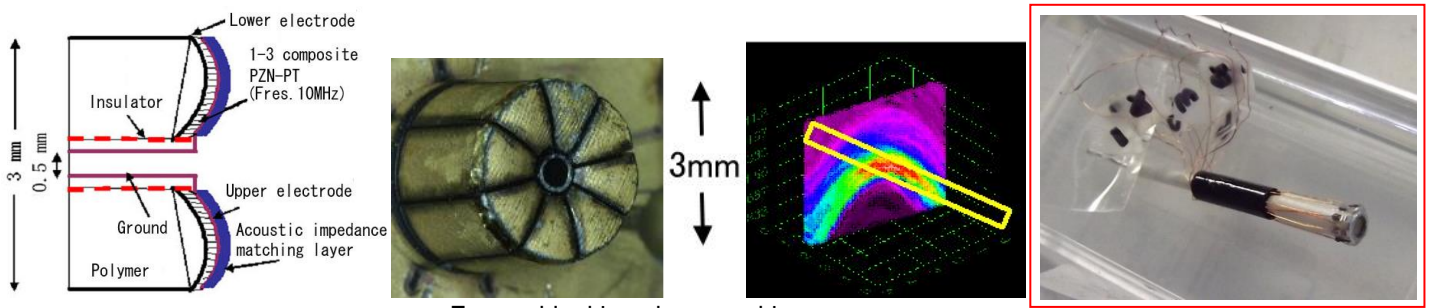


Peristaltic Motion System (Artificial earthworm)



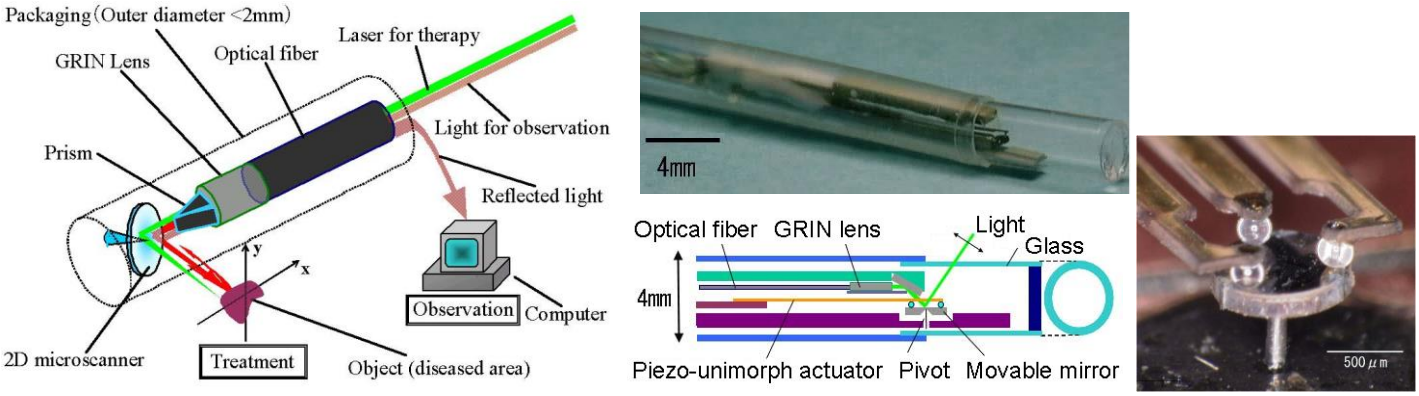
Reference : E.Shinohara, K.Minami and M.Esashi, Peristaltic Motion System Like Earthworm, Trans. IEE of Japan,119-E (1999) pp.334-339

D13 Imaging for minimal invasive medicine



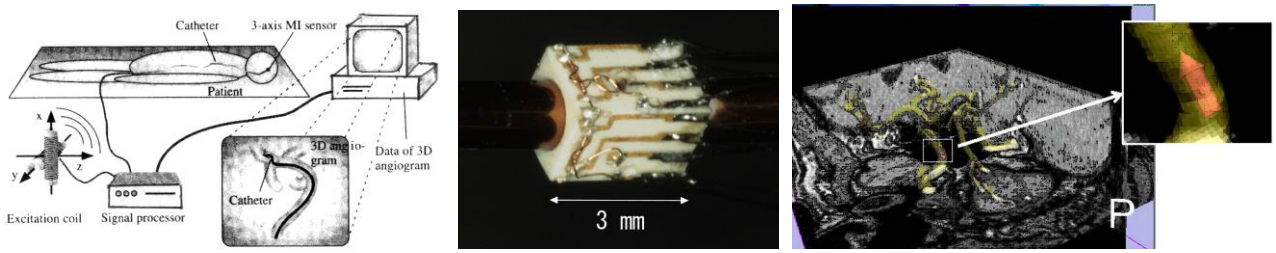
Forward looking ultrasound imager

Reference : J.-J.Chen, M.Esashi, O.Osato, K.Chihara, Y.Haga, Development of a Forward -looking Ultrasound Imager for Intravascular Treatment, Trans. of the Japanese Soc. For Medical and Biological Engng., 43 (2006) pp.553-559



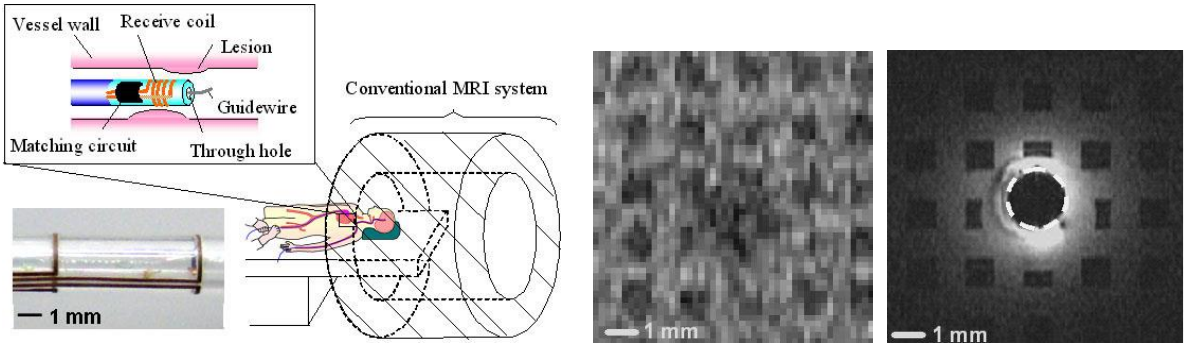
Optical scanner endoscope

Reference : H.Akahori, H.Wada, M.Esashi and Y.Haga, Tube Shape Piezoelectric 2D Microscanner for Minimally Invasive Laser Treatment, Technical Digest MEMS'2005 (2005) pp.76-79



Display system of position and direction for catheter tip using 3-axis magnetic sensor

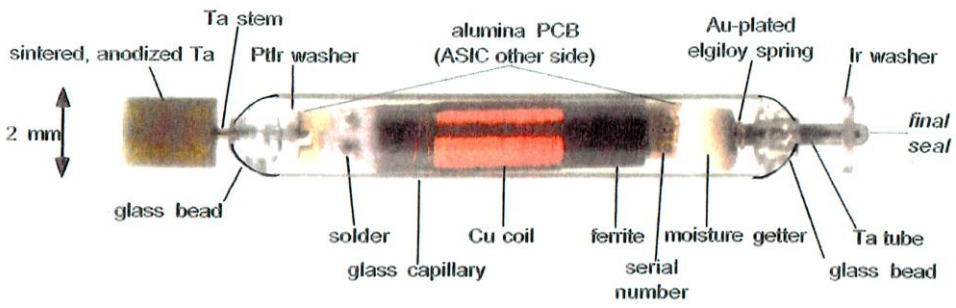
Reference : K.Totsu, Y.Haga and M.Esashi, Three-axis Magneto-impedance Effect Sensor System for Detecting Position and Orientation of Catheter Tip, Sensors and Actuators, A 111 (2004) pp.304-309

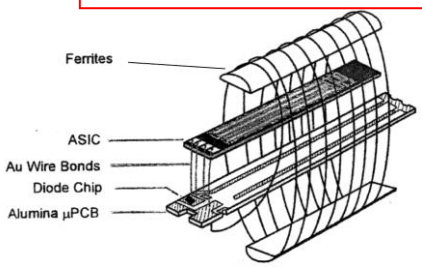


Receiving coil for MRI signal located at the catheter end

Reference : S.Goto, T.Matsunaga, Y.Matsuoka, K.Kuroda, M.Esashi and Y.Haga, Development of High-Resolution Intraluminal and Intravascular MRI Probe Using Microfabrication on Cylindrical Substrates, Tech. Digests of MEMS 2007 (2007) pp.329-332

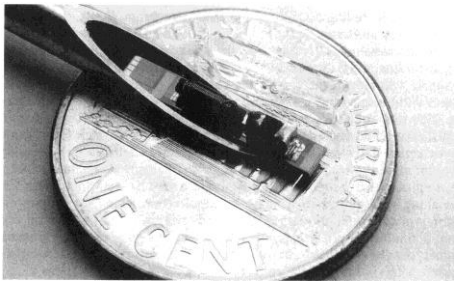
D14 Implantable stimulator

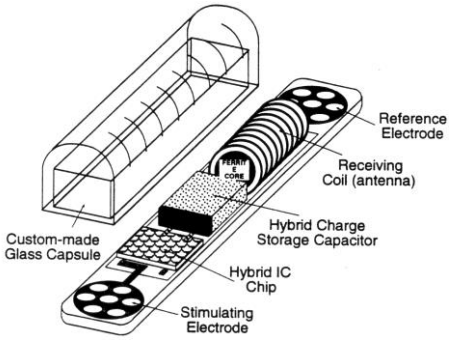


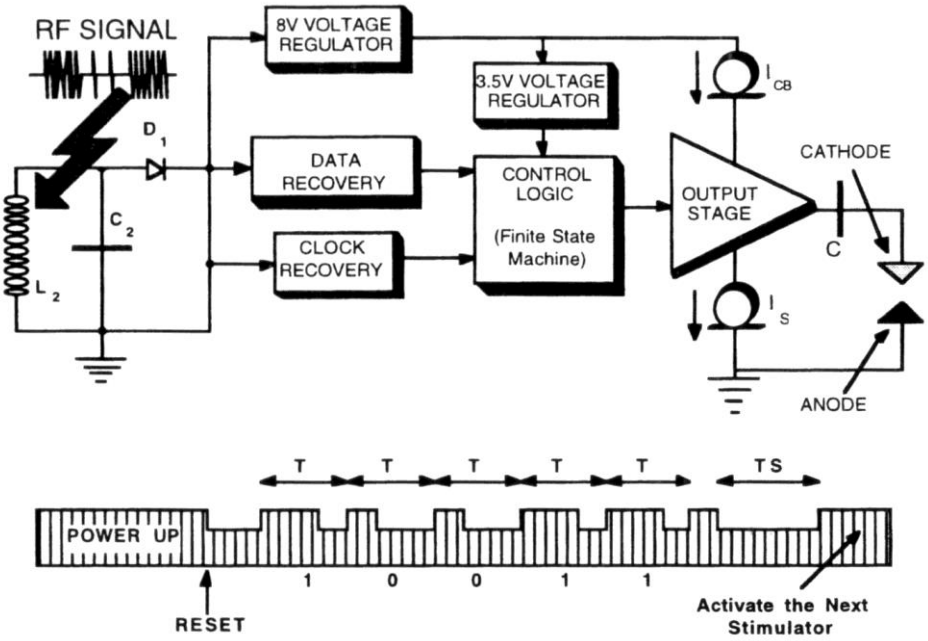


Implantable electrical stimulator BION (BIOnic Neuron) (Univ. of Southern California)

Reference : G.E.Loeb, F.J.R.Richmond, W.H.Moore and R.A.Peck, Design and Fabrication of Hermetic Microelectronic Implant, 1st Annual Internl. IEEE-EMBS Special Topic Conf. on Microtechnologies in Medicine & Biology (2000) pp.455-459







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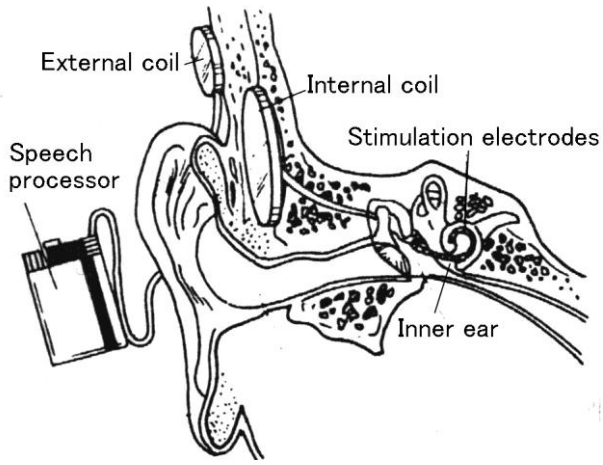

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